Technical

Chemical and Nutritional Evaluation of Chili (*Capsicum annum*) Seed Oil

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Alkali-refined red chili (*Capsicum annum*) seed oil was analyzed for free fatty acids, iodine value, saponification value, peroxide value and fatty acid composition, and the values were found to be close to those of edible oils. The alkali-refined chili oil (5% of diet), alcohol-treated chili oil (5%) and a mixture of alcohol-treated chili oil and peanut oil (5%+5%) were fed to adult male albino rats in natural diets for eight weeks. Digestibility was normal in all experimental animals and was on par with the peanut oil control. Serum lipid levels in the group fed alcohol-treated chili oil were slightly high compared to those in groups fed alkali-refined chili oil and peanut oil. Liver structure revealed no abnormalities.

Chili peppers (*Capsicum annum*) are cultivated in several parts of the world and extensively in India (1). Both green and red chilies are used to flavor food. Capsaicin, the pungent principle present in the inner walls of the fruit, is actually responsible for the strong, spicy flavor of the chilies (2,3). The seeds constitute 60% of the total weight of the dry fruit and contain 12-26% oil (1). The oil is rich in unsaturated fatty acids—linoleic (73.2%) and oleic (7.9), with small amounts of myristic (0.2%), palmitic (15.9%) and stearic (2.9%). The oil resembles most edible oils in its chemical and physical constants, i.e., iodine value, saponification value, unsaponifiable matter, refractive index and specific gravity (4). The chemical nature and the flavor components of red pepper powder and its effect on fat absorption were studied (5,6). While all this information is well documented, the effects of consuming the chili seed oil in biological systems is less understood and hence the present study was attempted.

MATERIALS AND METHODS

Chemical and fatty acid determination. Alkali-refined chili seed oil (RCSO) was analyzed for free fatty acids, iodine value, saponification value, unsaponifiable matter and peroxide value by adapting approved procedures (7). The fatty acid methyl esters were prepared by the method of Christie (8) and analyzed in a gas liquid chromatograph (Varian Model 3700), fitted with a flame ionization detector. The column (DEGS 6%) temperature of 180 C, injection port temperature of 200 C and detector temperature of 200 C were maintained, with nitrogen as carrier gas. The peaks obtained by injecting 1 μl methyl esters were identified by running a standard fatty acid mixture.

TABLE 1

Composition of Control and Experimental Diets

Ingredients	Control diets		Experimental diets		
	PNO[a] (5%)	PNO (10%)	RCSO[a] (5%)	ACSO[a] (5%)	PNO+ACSO (5%) (5%)
Rice flour	45	40	45	45	40
Roasted green gram dhal flour	40	40	40	40	40
Peanut oil	4	9	–	–	4
Refined chili seed oil	–	–	4	–	5
Alcohol-treated chili seed oil	–	–	–	4	–
Sugar	5	5	5	5	5
Salt mixture[b]	4	4	4	4	4
Water-soluble vitamin mixture[c]	1	1	1	1	1
Fat-soluble vitamin mixture[d]	1	1	1	1	1

[a]PNO, peanut oil; RCSO, refined chili seed oil; ACSO, alcohol-treated chili seed oil.
[b]Salt mixture-NaC1, 139.3 g; KI, 0.79 g; KH_2PO_4, 389.0 g; $MgSO_4$ (anhydrous), 57.3 g; $CaCo_3$, 381.4 g; $FeSO_4 \cdot 7H_2O$, 27.0 g; $MnSO_4 \cdot H_2O$, 4.01 g; $ZnsO_4 \cdot 7H_2O$, 0.548 g; $CuSO_4 \cdot 5H_2O$, 0.477 g; $CoC1_2 \cdot 6H_2O$, 0.23 g.
[c]Vitaminized starch: 1 g corn starch contained vitamin K (menadione), 0.5 mg; thiamine, 0.5 mg; riboflavin, 1.0 mg; pyridoxine, 0.4 mg; calcium pantothenate, 4.0 mg; niacin, 4.0 mg; choline, 200 mg; inositol, 25 mg; paraaminobenzoic acid, 10 mg; vitamin B_{12}, 2 μg; biotin, 0.02 mg; folic acid, 0.2 mg.
[d]Vitaminized oil: 1 g of the oil contained retinol, 300 μg; vitamin D_2, 2.5 μg; α-tocopherol acetate, 10 mg.

TABLE 2

Lipid, Protein and Energy Values in Control and Experimental Diets[a]

Ingredients	Control diets		Experimental diets		
	PNO (5%)	PNO (10%)	RCSO (5%)	ACSO (5%)	PNO+ACSO (5%) (5%)
Lipid (g)	5	10	5	5	10
Protein (g)	12	12	12	12	12
Energy (Kcal)	360	387	360	360	387

[a]Abbreviations as in Table 1.

Two kg of alkali-refined chili seed oil were treated with ethanol to partly remove the traces of capsaicin present, as indicated by Srinivasan (3), and then water-washed to eliminate alcohol (alcohol=treated chili seed oil) (ACSO).

Biological study. Forty adult male albino rats weighing 146-148 g were divided into five groups of eight animals each. The animals were fed one of the diets given in Table 1, ad libitum; refined peanut oil (PNO) was reference. The salt mixture, vitaminized starch and vitaminized oil were prepared according to Indian Standard Institute specifications (9). The diets so prepared provided lipids, calories and proteins as indicated in Table 2.

The feeding as carried out for a period of eight weeks, and the food intake of all animals was recorded each day. The rats were carefully supervised for any clinical signs. Toward the end of feeding, the final weight of all animals was recorded.

Digestibility study. Three days before termination of feeding, the feces of both control and experimental groups was collected and analyzed for lipid excretion (10). After making correction for metabolic fat, the true digestibility was computed.

Collection of blood and liver tissues. On completion of eight weeks feeding, the blood and livers from control and experimental animals were collected and weighed. From each liver a small portion from the right lobe was cut and preserved in 10% neutral buffered formalin for histopathological examination. The rest of the liver tissues were weighed and homogenized with chloroform-methanol (2:1) to a final 20-fold volume, filtered and kept ready for lipid analysis.

Analysis of serum and liver homogenates for lipids. The lipid components analyzed in serum and liver were total lipids (10,11), total cholesterol (12), free cholesterol (13), phospholipids (14) and triglycerides (15).

Histopathological study. The processing of liver sections for histopathological study was done by the method of Culling (16). The results of biochemical analyses were subjected to tests of significance (17).

RESULTS AND DISCUSSION

Chemical nature and fatty acid composition. The chemical characteristics of the alkali-refined chili oil (Table 3) and the component fatty acids (Table 4) were found to be close to peanut oil and to the values reported for most commonly used edible oils except for I.V. The chili oil had about 18.5% total saturated fatty acids and 81.5% unsaturated fatty acids, with 70.6% linoleic acid content, while peanut oil has 12% total saturated fatty acids and 88% unsaturated acids with more oleic (58%) than linoleic acid (30%). The linoleic acid in chili oil is more than double the amount present in peanut oil.

Feed efficiency and digestibility. The feed efficiency in rats fed diets containing RCSO (5%), ACSO (5%), or a mixture of ACSO+PNO (5%+5%) were comparable to PNO (5% and 10%) control groups (Table 5). The true digestibility on feeding the different chili oil diets was also comparable to PNO.

Lipid composition in tissues. Total lipids, total cholesterol, free cholesterol and triglycerides were high in the blood samples of chili seed oil groups compared to control groups fed PNO (Table 6). The highest lipid levels were seen in the ACSO group, followed by the RCSO group. The mixutre of RCSO 5%+PNO 5% did not show a large increase, but compared to the 5% and 10% PNO control groups, these levels were still considered high. Despite the low lipid level in the diet, the pronounced increase in blood lipid levels can be related to large food intake by the adult rats, or possibly to

TABLE 3

Chemical Characteristics of Chili Oil Compared With Peanut Oil

	Chili oil	Peanut oil
Free fatty acids (FFA) (as oleic acid %)	0.8	0.8
Iodine value (Wijs) (IV)	136.0	92.0
Saponification value (SV)	194.0	193.0
Peroxide value (POV) (Meq O_2/kg oil)	4.2	0.5

TABLE 4

Fatty Acids in Chili Seed Oil and Peanut Oil

Fatty acid	% level in	
	Chili oil	Peanut Oil
Palmitic acid (C16)	16.36	9.0
Stearic acid (C18)	2.15	3.0
Oleic acid (C18:1)	10.90	58.0
Linoleic acid (C18:2)	70.59	30.0

TABLE 5

Food Efficiency and Digestibility in Control and Experimental Rats

Parameters	Control		Experimental		
	PNO (5%)	PNO (10%)	RCSO (5%)	ACSO (5%)	RCSO+PNO (5%) (5%)
Food intake(g)	752	796	812	840	778
Weight gain(g)	140	145	146	153	143
PER (weight gain/ food intake)	0.18	0.18	0.18	0.18	0.18
True digestibility (%)	97	97	97	97	97

Abbreviations as in Table 1.

biosynthesis from acetyl groups (18) in the liver. Phospholipid levels in serum were observed to be unaltered.

The lipid composition of the liver did not change to alarming levels due to chili oil feeding. However, the total lipid level in the ACSO (5%) group was high compared to the other groups (Table 7). This increase may be associated with the large food intake, which influenced the liver weight, consequently stimulating lipid synthesis in the liver (18). Further examination of the liver sections showed that the liver architecture of the experimental rats, excepting the group fed ACSO (5%), appeared normal without any fatty infiltration or necrotic changes, and they were comparable to control groups fed 5% and 10% PNO. In the ACSO (5%) group a very mild fatty infiltration was noticed in 90% of the animals, but the necrotic changes leading to liver damage were absent.

For ages, green chili or red pepper have been used in many ways for culinary and medicinal purposes. No harmful effects have been reported upon normal intake. The oil extracted from the seeds, if refined, may not pose a big problem to human beings, as shown in this study by rat feeding trials. Chili seed oil has the added advantage that it can substitute for spices during food preparation because the oil is still pungent. The use of

TABLE 6

Lipid Components in Serum

Lipid components	PNO (5%)	PNO (10%)	RCSO (5%)	ACSO (5%)	RCSO+PNO (5%) (5%)
Total lipids (mg/100 ml)	455 ± 37[a]	463 ± 26[a]	548 ± 34[b]	563 ± 34[b,c]	495 ± 38[a,b]
Total cholesterol (mg/100ml)	75 ± 50	78 ± 5[a]	87 ± 6[a]	90 ± 10[b]	82 ± 7[a,b]
Free cholesterol (mg/100 ml)	22 ± 2[a]	23 ± 2[a]	25 ± 2[b]	27 ± 3[c]	24 ± 2[a,b]
Phospholipids (mg/100 ml)	95 ± 5	93 ± 5	92 ± 6	94 ± 11	90 ± 7
Triglycerides (mg/100 ml)	283 ± 29[a]	293 ± 18[a,b]	368 ± 21[c]	379 ± 43[c]	321 ± 25[b]

Abbreviations as in Table 1.
(±) Standard deviation.
Figures with same subscript are not statistically different (P<0.5)

TABLE 7

Lipid Components in Liver

Lipid component	PNO (5%)	PNO (10%)	RCSO (5%)	ACSO (5%)	RCSO+PNO (10%)
Liver weight (g)	8.1 ± 1.0	8.2 ± 1.1	8.4 ± 1.5	9.6 ± 1.6	8.3 ± 1.0
Liver weight as % of body weight	2.6 ± 0.2	3.0 ± 0.4	2.8 ± 0.4	3.2 ± 0.3	2.8 ± 0.4
Total lipids (mg/g)	114.0 ± 13.0	117.0 ± 13.0	118.0 ± 13.0	119.0 ± 19.0	116.0 ± 11.0
Total cholesterol (mg/g)	12.0 ± 1.0	12.0 ± 1.0	12.1 ± 1.0	12.4 ± 2.0	12.1 ± 1.0
Free cholesterol (mg/g)	4.7 ± 0.5	4.8 ± 0.5	4.9 ± 0.5	5.0 ± 0.7	4.9 ± 0.6
Phospholipids (mg/g)	37.5 ± 4.0	38.0 ± 4.0	39.0 ± 5.0	39.0 ± 6.0	38.8 ± 4.0
Triglycerides (mg/g)	64.0 ± 7.0	65.0 ± 6.0	66.0 ± 7.0	65.0 ± 6.0	66.0 ± 7.0

Abbreviations as in Table 1.
(±) Standard deviation.

chili oil may play a dual role of supplying essential fatty acids and contributing flavor, both in normal cooking and in pickle preparation. This oil should be considered for large-scale production, instead of discarding the seed available in the market, to partly improve the oil situation in developing countries. This oil, however, cannot be recommended for deep frying because it produces strong pungent odor upon heating to high temperatures.

ACKNOWLEDGMENT

The authors thank the Andhra Pradesh Agricultural University, Hyderabad, for facilitating the study and the Oil Technological Research Institute, Ananthapur, for supplying the chili seed oil.

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[Received April 3, 1986]